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PRELIMINARY WATER QUALITY CONTROL METHOD STUDY. VIRGIN RIVER, UTAH, ARIZONA, AND NEVADA. APPENDIX B 1

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Feasible measures of control of slainity in the Virgin River were proposed in a study that considered the water quality and quantity of the river before and after the Dixie Project and the Moapa Valley Pumping Project were completed. The Virgin River contributes approximately 3 percent of the total salt load to Lake Mead Reservoir, but increased use of the river flow will increase the concentration of TDS in the river and in Lake Mead. Water quality benefits and costs related to the control measures are discussed.

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APPENDIX B 1

PRELIMINARY WATER QUALITY CONTROL METHOD STUDY
VIRGIN RIVER
UTAH, ARIZONA, AND NEVADA

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Bureau of State Services
Division of Water Supply and Pollution Control
Region VIII

Colorado River Basin Water Quality Control Project

September 1965

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APPENDIX B 1

PRELIMINARY WATER QUALITY CONTROL METHOD STUDY
VIRGIN RIVER
UTAH, ARIZONA AND NEVADA

I. INTRODUCTION

A. Purpose and Scope

The purpose of this report is to propose feasible measures of control of salinity in the Virgin River. The Virgin River discharges 1,090 tons per day of salt into Lake Mead and ultimately to the Lower Main Stem of the Colorado River. This load constitutes approximately 3 percent of the load being discharged to the Lower Main Stem. The quality benefits derived from the reduction of the salinity load and accruable to the water users in the Lower Main Stem and in the southern Nevada area will be determined. The scope of the project is the reach of the Virgin River from the proposed Virgin Reservoir, downstream to the Overton Arm of Lake Mead. This area is divided into three parts for quality determinations, namely; La Verkin Springs area, the Littlefield Springs area, and the Overton Arm area.

This study considers the water quality and quantity of the Virgin River before and after the Dixie Project and the Moapa Valley Pumping Project are in effect. This includes the diversions of the Dixie Project from the Virgin River, the discharge of the La Verkin Springs, the return flows from irrigation in the Santa Clara and Virgin River areas, the discharges from the Littlefield Springs, the consumptive use below Littlefield for irrigation, phreatophyte losses, the contribution from natural runoff and various springs in the Overton Arm area, and irrigation returns to the Muddy River. Based upon the total reach of the river, the estimated dissolved solid load which

enters Lake Mead before and after the development of the Bureau of Reclamation projects is 398,000 and 433,000 tons/year respectively.

II. SUMMARY OF FINDINGS AND CONCLUSIONS

A. Summary of Findings

The Virgin River contributes approximately 3 percent of the total salt load to Lake Mead Reservoir.

The saline La Verkin Springs at Hurricane, Utah contribute approximately 30 percent of the Virgin River load. The Littlefield Springs contribute about 37 percent and the remainder comes from natural runoff and irrigation returns to the Virgin River. The increase in salinity from the Dixie Project will have some adverse effect for users of Virgin River flows in Arizona and Nevada, but the principal damages will be to the downstream users of Lake Mead water. Benefits derived from the control of salinity in the Virgin River will be realized principally from these downstream municipal and industrial users.

The proposed Moapa Valley Pumping Project will cause an increase in the salinity concentration of Lake Mead, but probably not in the salt load. The plan provides for pumping Lake Mead water to the lower Moapa Valley for irrigation purposes. This is to be supplemented by irrigation return flows from the upper Moapa Valley.

Two additional sources cause salinity load and concentration increases in the Overton Arm of Lake Mead. One source is a series of springs discharging along a fault line, as described in the section on Geology. Another sources is the contribution during periods of runoff when the overland flow picks up from the ground surface a salt residue that accumulates continuously from the evaporation of shallow, saline ground water.

B. Conclusions

The increased use of the Virgin River flow will increase the concentration of TDS in the river and in Lake Mead.

The control of salinity in the Virgin River area may be accomplished by various methods. The method which is the most economically feasible, however, is the desalination of the combined flows from the springs and the return flows from irrigation at the lower end of the Virgin River for M&I use in Las Vegas. The proposed plan would improve water quality at Hoover Dam by 15 mg/l.

Other water quality benefits such as improvement in the total ~~quality~~ water supply to Las Vegas area and in the improvement in the return flows in Las Vegas Wash have been estimated.

The annual cost of the proposed plan is estimated to be $12,900,000. Based upon the sale of the produced water at $0.50 per 1,000 gallons, the net annual cost would only amount to $147,700. Monetary benefits for water quality improvement have not been established.

The cooperation of interested Federal agencies, such as the Office of Saline Water, and the Bureau of Reclamation, both in the Department of the Interior; the Atomic Energy Commission; and the Department of Health, Education, and Welfare, is necessary in the implementation of this plan.

III. PROJECT DESCRIPTION

The Virgin River Basin is an interstate stream which heads in the mountains of western Kane and southeastern Iron Counties, Utah; flows in a southwesterly direction through Washington County, Utah; crosses the northwestern corner of Mohave County, Arizona; and discharges into Lake Mead in Clark County, Nevada (see Figure B1-1). It drains an area of 6,000 square miles, of which 2,900 square miles are in Utah, 1,100 square miles in Nevada, and some 2,000 square miles in Arizona. The Muddy River is a tributary to the Virgin River and its confluence is at the upper end of the Overton Arm of Lake Mead. The Overton Arm was formed by the inundation of the Virgin River channel during the filling of Lake Mead behind Hoover Dam.

A. Physical Features

Topography throughout most of the area is controlled by the tilted and warped underlying strata, typical of fault block structural deformation. Probably, the most important feature is the great Hurricane Fault which is located near the easterly edge of the Basin. The native vegetation consists mainly of scattered perennial shrubs and grasses with an abundance of annual weeds and grasses when moisture conditions are favorable. The lower reaches of the Virgin River are infested with phreatophytes, predominately salt cedar.

Climate in the area is characterized by a small amount of precipitation and an abundance of sunshine; short, mild winters; long, hot summers; and wide extremes of daily temperatures. Mean annual precipitation is approximately 8 1/2 inches. Temperature extremes vary from -11°F to a maximum of 116°F. Free water evaporation rates in the area vary from 58 inches to 82 inches annually. An average of 85 inches is reported for Lake Mead. Principal

towns in the area are St. George, Hurricane, Santa Clara, La Verkin, and Washington, Utah with a combined population of 7,482 and a total population within Washington County, Utah of 10,271. Population in Arizona and Nevada amounts to approximately 2,000.

B. Geology - Virgin River Area

The Virgin River area is located in the Basin and Range province of southwestern Utah and adjacent parts of northwestern Arizona and southeastern Nevada.

The principal geologic strata of this area are of the Mesozoic and Peleozoic Eras. The typical fault block structure of the Basin and Range province is very much in evidence and has produced the usual associated alluvial fan and other fluvial deposition of the Tertiary Era. Volcanics of late Tertiary time are also in evidence from the presence of many volcanic cones, necks, and lava flows.

The Virgin River cuts across this area in a southwesterly direction from Zion National Park to Lake Mead and is incised into the fault blocks in a transverse direction.

The La Verkin Springs emerge from the Kaibab limestone of Permian age at the bottom of the Virgin River Canyon near La Verkin and Hurricane, Utah. The springs occur just east of the north-south trending Hurricane fault. Downstream, southwest of St. George, Utah, the Virgin River cuts through the Beaver Dam Mountains.

As the Virgin River enters the east front of the Beaver Dam Mountains, it passes through a cut known as the "First Narrows". The river winds its way through a deeply incised channel, and near the west front of the Beaver Dam Mountains, passes through a deep cut known as the "Narrows".

As the Virgin River emerges from the "Narrows", it cuts across an alluvial trough that is underlain by limestone strata of the Paleozoic Era. About five miles downstream from the "Narrows", at Littlefield, Arizona, another set of springs emerges along the banks of the Virgin River. The springs along the east side of the river discharge from the Redwall limestone of Mississippian age. The springs on the west side of the Virgin River at Littlefield discharge from the overlying alluvium and are fed mainly from the area of Beaver Dam Wash.

C. Geology - Rogers Spring Area

The Rogers Spring area on the west side of Lake Mead is about ten miles south of Overton, Nevada. Rogers Spring is the largest of several springs that emerge from the Rogers Spring limestone of Mississippian age along the east side of the northeast-southwest trending fault. The springs discharge to an area of alluvium that occurs between the above-mentioned fault and the shore of Lake Mead.

IV. WATER RESOURCES OF STUDY AREA

A. Water Quality and Quantity

Water resources in the area come primarily from the Virgin River and the Santa Clara River. The mean annual runoff at the Virgin City gaging station for the 32-year period from 1926 through 1958 was 132,000 acre feet. Most of the runoff occurs from March through May from melting snows in the mountains and high plateaus. The Santa Clara River is a tributary to the Virgin River near St. George (see Location Map). The mean annual runoff of the Santa Clara River above Windsor Dam for the years 1926 to 1958 was 18,130 acre feet. This figure includes adjustments for upstream reservoir operations.

A large amount of this runoff is now lost as flood discharges. Subsequent to the development of the Dixie Project, this will be avoided through regulated releases of waters for irrigation and other uses. There will be a reservoir of stored water that will be used as a base for increased agricultural and industrial development.

Most municipal supplies are derived from springs and these will be adequate for the forseeable future except for the city of St. George, Utah. The communities of St. George and Santa Clara have expressed interest in obtaining water from the Dixie Project along with Cedar City, Utah which is outside of the Virgin River Basin.

The average flow at the Virgin River gaging station below Virgin City for the years 1951 to 1956 was 139 cfs with a TDS concentration of 489 mg/l, and a total salt load of 190 tons per day. Below the Virgin City gaging

station, water is diverted into the La Verkin and Hurricane areas for irrigation. Downstream from the diversion, the La Verkin Springs discharge into the Virgin River. These springs flow at a constant 12 cfs with a TDS concentration of 10,000 mg/l. The TDS contribution from the La Verkin Springs is 324 tons per day. At Littlefield, Arizona, the U. S. Geological Survey operates a gaging and chemical quality station. The data from this station was used for this study. Above this station, the Littlefield Springs enter the Virgin River with a flow of approximately 60 cfs and a TDS concentration of 2,500 mg/l. The load contributed is 405 tons per day. The additional 170 tons per day of TDS load is contributed by irrigation and natural runoff.

At the present time there is enough flow in the Virgin River so that the flow passing the Hurricane-La Verkin diversion, in combination with Santa Clara River flow, provides enough dilution of La Verkin Springs discharge, to make the combined flow useable for irrigation by downstream users.

Future conditions, after the Dixie Project is constructed, will not provide for releases from the reservoir on the Virgin River or the one on the Santa Clara River for the dilution of saline spring flows. At that time, the downstream users will have available only the La Verkin Spring discharge, irrigation return flows, tributary runoff, and Littlefield Spring flows. Even with the resultant increased concentration from 1,560 mg/l to 2,370 mg/l, the present users will be affected only by the increased water requirement needed for leaching. This increased use will, in turn, cause further deterioration of water quality.

Table B1-1 shows the present monthly water quantity and quality conditions at Littlefield, Arizona and the estimated downstream condition

TABLE B1-1

PRESENT CONDITIONS - FLOW AND QUALITY FROM VIRGIN RIVER TO LAKE MEAD
(flow and consumptive use in 1000 acre foot units)

Date	Littlefield Flow[1]	Littlefield TDS mg/l	Littlefield TDS tons[2]	Phreatophyte Losses Littlefield to Mesquite-Riverside area[3] Consumptive Use	Irrigation losses in Mesquite to Riverside area[4] Consumptive Use	Virgin River @ Overton Arm[5] Flow	Virgin River @ Overton Arm[5] TDS mg/l	Virgin River @ Overton Arm[5] TDS tons
January	14.0	1,800	34,500	0.9		13.1	1,950	
February	18.4	1,530	38,500	0.9		17.5	1,630	
March	21.9	1,160	34,500	1.8		20.1	1,270	
April	25.6	1,020	35,700	2.7	1.6	21.3	1,240	
May	25.9	935	33,100	2.7	1.6	21.6	1,130	
June	6.8	1,870	17,400	3.6	1.6	1.6	8,050	
July	7.5	2,280	23,400	4.5	1.6	1.4	12,400	
August	14.6	2,050	41,000	4.5	1.6	8.5	3,570	
September	9.3	2,130	27,100	3.6		5.7	3,520	
October	9.7	2,320	30,800	2.7		7.0	3,250	
November	11.4	1,950	30,400	1.8		9.6	2,360	
December	13.3	1,870	34,000	0.9		12.4	2,020	
TOTAL	178.4		380,000	30.6	8.0	139.8		380,000
MEAN		1,560					2,010	
[6] Add Rogers Spring (annual)						0.73		2,950
Add Overton Arm area runoff (annual)						0.37		14,750
Total contribution to Lake Mead						141.0	2,080	397,700

1 From Geological Survey WSP. Average conditions for WY 1930-1955. Dixie Project Report, BuRec 1963.

2 Data generated from rating curve based on 10-day composites from June 1949. Dixie Project Report, BuRec 1963 (House Document #86).

3 Phreatophyte consumptive use based on 3.4 feet yearly consumption (Pacific Southwest Water Plan - Water Salvage Report) on 9000 acres and distributed proportional to monthly evaporation taken from Dixie Project Report, BuRec 1963.

4 Based on 4000 acres irrigated (House Document #86). Used 4.0 ft. yearly diversion over 5 month period with 1/2 consumptively used.

5 Littlefield conditions corrected for phreatophyte and irrigation losses. Tonnage same as Littlefield.

6 Rogers Spring - 1 cfs @ 3000 mg/l; runoff from Overton Arm area 1/2 cfs @ 30,000 mg/l.

as affected by irrigation and phreatophyte consumptive use, assuming a salt balance in the computed reach. This resulting downstream condition occurs at a point where the Virgin River enters the Overton Arm. This contribution is then combined with the contribution from the Rogers Spring area and the natural runoff from the Overton Arm area. Monthly distribution of natural runoff area was not analyzed, so this quality and quantity condition was added along with Rogers Spring area as an average annual contribution. Rogers Spring has a flow of 1 cfs at 3,000 mg/l.

The total runoff and TDS load for the Virgin River and the Overton Arm area is 141,000 acre feet per year and 398,000 tons of TDS at a computed concentration of 2,080 mg/l.

Table B1-2 shows the effect of the same factors on the same reach of the river following the development of the Dixie Project, the Moapa Valley Pumping Project, and the proposed desalination plant. The flow at Littlefield will then be comprised of tributary flows, return flows from Hurricane and Santa Clara diversions of the Dixie Project and La Verkin and Littlefield Springs area. The effect of the Dixie Project will be a deterioration of quality caused by consumptive use and decreased flows. Due to an out-of-basin diversion, there is also a decrease in tonnage. The lower flows tend to aggravate the effects of downstream consumptive uses as compared to present effects, and it is estimated that the TDS concentration in the Virgin River, above the Overton Arm, will be 3,560 mgl. This is 1,550 mg/l greater than present conditions. The effects of the Moapa Valley Pumping Project on Muddy River discharge to Lake Mead were computed assuming a salt balance and return flows of one-half of the quantity pumped from Lake Mead. The quantity to be pumped from Lake

TABLE B1-2

AFTER DEVELOPMENT OF DIXIE & MOAPA VALLEY PROJECTS - ESTIMATED FLOW & QUALITY CONTRIBUTIONS FROM VIRGIN RIVER TO PROPOSED PLANT

(flow and consumptive use in 1000 acre foot units)

	Littlefield[1]			Phreatophyte Losses Littlefield to Mesquite-Riverside Area[2]	Irrigation Losses in Mesquite to Riverside Area[3]	Virgin River @ Overton Arm[4]		
	Flow	TDS		Consumptive Use	Consumptive Use	Flow	TDS	
Date		mg/l	tons				mg/l	tons
January	10.4	2,450	34,756	0.9		9.5	2,700	
February	12.5	2,160	36,743	0.9		11.6	2,340	
March	11.2	1,870	28,394	1.8		9.4	2,230	
April	9.8	2,140	28,512	2.7	1.6	5.5	3,840	
May	10.6	1,970	28,414	2.7	1.6	6.3	3,340	
June	5.9	2,370	19,024	3.6	1.6	0.7	20,000	
July	7.8	2,340	24,783	4.5	1.6	1.7	11,400	
August	13.9	2,260	42,642	4.5	1.6	7.8	4,050	
September	7.6	2,840	29,421	3.6		4.0	5,430	
October	7.5	3,270	33,351	2.7		4.8	5,140	
November	9.8	2,670	35,622	1.8		8.0	3,290	
December	9.8	2,600	34,718	0.9		8.9	2,890	
TOTAL	116.8		376,380[6]	30.6	8.0	78.2		376,380
MEAN		2,370					3,560	
[5] Add Rogers Spring (annual)						.73		2,950
Add Overton Arm area runoff (annual)						.37		14,750
Add Moapa Valley Project returns (annual)						15.5		39,000
Total contribution to Proposed Plant						94.8	3,370	433,080

1 From Dixie Project Report, BuRec, House Document #86, 1963, including La Verkin Spring flow.
2 Same as for table showing Present Conditions.
3 Same as for table showing Present Conditions.
4 Littlefield conditions corrected for phreatophyte & irrigation losses. Tonnage same as Littlefield.
5 Rogers Spring & Overton Arm area runoff same as for Present Conditions. For Moapa Valley Pumping Project, divert 22,000 acre feet @ 680 mg/l TDS, and 9,000 acre feet @ 1,500 mg/l from upper Moapa Valley. Return under salt balance @ 1/2 flow (see Moapa Valley Report, BuRec 1963).
6 Reduction in TDS load caused by out-of-basin diversion in the Dixie Project.

Mead as reported in the Moapa Valley Pumping Project Report is 22,000 acre feet per year. The same report indicates that a 9,000 acre foot per year flow from the upper Moapa Valley will also be used in the lower valley. The effect of this flow is estimated using the same assumption. The quality of these flows is not reported, but for the purposes of this report, it is assumed that the water pumped from Lake Mead will have a TDS concentration of 680 mg/l and the return flows from the upper Moapa Valley will have a TDS concentration of 1,500 mg/l. The combined return flow quantity and quality from the project area are estimated to be 15,500 acre feet per year, with salt load of 39,000 tons. This contribution, along with those from the Virgin River, Rogers Spring area, and the natural runoff in Overton Arm area, comprise the total Virgin River contribution to Lake Mead, amounting to 94,800 acre feet per year and 433,000 tons of salt. The effective TDS concentration is 3,370 mg/l.

V. CONTROL PLANS

A. Alternative Plans

There are several alternative plans for controlling salinity in the Virgin River involving combinations of either or both of the principal spring areas (La Verkin and Littlefield) with various methods of removing the salt load. These methods include ponding and evaporation at each site and/or saline water conversion at each site. There are advantages and disadvantages for each plan. The advantages of ponding are low initial cost (depending on proximity of ponding area to saline source) and low operating cost. One large disadvantage is the loss of water. Another disadvantage is the need for intercepting the saline source prior to its entering the water course. Desalination has the disadvantage of high cost, but an advantage over ponding is that it is a reclamation process in which most of the water is recovered for reuse. The saline source is converted to fresh water at a cost acceptable for municipal and industrial use.

These advantages and disadvantages were considered at each site. In the La Verkin Springs area, ponding and evaporation is not a practical method of disposal because a suitable area for ponding is too far away to be economically feasible. This is unfortunate because the method would remove 118,000 tons per year of TDS from the Virgin River at a loss of only 8,600 acre feet per year. Water quality at Littlefield would be improved by a reduction in TDS concentration of 420 mg/l. This would benefit the users in the Mesquite to Riverside, Nevada area. A breakdown of monthly Virgin River flow and quality at Littlefield, for the condition assuming the removal of La Verkin Springs, is tabulated in the Bureau of Reclamation Dixie Project

Report.

The disposal of Littlefield Springs by the same method, either in conjunction with or independent of La Verkin Springs, is not practical because of the large flow involved. Littlefield Springs annual flow is 43,200 acre feet and the salt load is 148,000 tons (2,500 mg/1). This flow is necessary to insure adequate water for irrigators in the Mesquite to Riverside area. Any control of these springs would require either reclamation of the spring water, and additional water supply, or some adjustment made for water rights. The second remedy could be partially obtained downstream by phreatophyte control. It is estimated that by controlling phreatophytes, 31,000 acre feet could be conserved. This control, in conjunction with the ponding and evaporating of Littlefield Springs, would reduce the net annual loss to only 12,000 acre feet, but would increase control costs.

The use of saline water conversion at both spring sites was considered. It is obvious that desalination would provide water of improved quality for water users along the lower Virgin River, but it is also obvious that the present water users could not afford this high cost water. The use of this process for Littlefield Springs is complicated by the loss of about 14,000 acre feet of water in the waste brine.

In summary, neither ponding and evaporation nor saline water conversion is feasible at these sites from the standpoint of aiding water users in the lower Virgin River or the Colorado River. In conjunction with this conclusion, the following is quoted from House Document #86, a report on the Dixie Project, Utah regarding the salinity problem of the La Verkin Springs:

"The quality of water problem presented by the highly mineralized

> discharge of 12 cfs from the La Verkin thermal springs has been given considerable study in reconnaissance level investigations. A search for an nonirrigable area suitable for evaporation ponds revealed one site which could be reached with a gravity flow adequate approximately 9 miles in length. A reconnaissance design estimate indicated that only 65 percent, or less, of the discharge from the springs could be disposed of at this site. Because of the high estimated cost and inadequate capacity, a disposal facility at this site is considered to be infeasible."

Later, the following is quoted from the same document:

> "Public Law 87-295, 87th Congress, HR 7916, approved September 22, 1961 provides authority which permit the Department of the Interior to expand and extend the saline water conversion program. Should necessary funds be made available, it is possible that a thorough investigation of the La Verkin Springs situation could be made by the Office of Saline Water. On the basis of such evaluation, the Office of Saline Water could make specific recommendations relative to the size and cost of the saline water plant required as well as a method of disposing of any by-products resulting from this operation."

From the same document, in explanation of requested project development appropriation:

> ". . . A lump sum figure of $2,000,000 has been included in the cost estimate, either to provide a feasible method of control or to indemnify downstream interests for damages which might develop following development of the Dixie Project."

There is some uncertainty as to whether desalination can be justified to improve water for agricultural use, but it is practical and economically feasible to use desalination as a control method if the effluent were to be used for municipal and/or industrial purposes. In the La Verkin and Hurricane areas, the desalination of 8,000,000 gallons per day (12 cfs) is in excess of any local municipal or industrial need.

Another plan which appears feasible considers the collection of the waters of the Virgin River and the desalination of these waters for a potable water supply for the municipal and industrial users in the Las Vegas area.

After the Dixie Project and the Moapa Valley Pumping Project are in operation, the flows of the Muddy River and the Virgin River will consist mainly of mineral springs and irrigation return flows. The Virgin and Muddy Rivers will be used essentially as drains to collect and convey irrigation returns and natural saline spring waters to Lake Mead. These flows, if desalinated to a TDS concentration of 500 mg/l, or less, could be economically conveyed to the Las Vegas area (current population 110,000 est.) for municipal and industrial use. Adjacent to the plant site, there is land available for the disposal of the highly brackish effluent from the desalination plant. A plant of this size, 70 MGD, has not been constructed to date. The Department of Health, Education, and Welfare and the Department of the Interior should coordinate their efforts and consult with the Office of Saline Water and the Atomic Energy Commission in a feasibility study of this plan with regard to the type of plant to use and associated fuel requirements.

The quality of the treated water will be determined by the type of desalination process employed. For electrodialysis, the quality will not exceed 500 mg/l. For an evaporation process, the ~~evaporate~~ condensate has essentially a zero TDS. By treating less water and diluting it with raw water, the TDS can be adjusted to any value between zero and the TDS concentration of the raw water. Higher quality water is thus gained at the expense of losing more water to the waste brine. The type of fuel used will also effect the cost of the overall plant operation.

B. Control Plan Details

The plan to accomplish the desired salinity reduction in the Virgin River would be to construct a storage dam at the north end of the Overton Arm of Lake Mead to divert the saline water of the Virgin and Muddy Rivers into the forebay of a 70 MGD desalination plant. This storage dam would be located near the St. Thomas Wash inlet of the Overton Arm (see Figures B1-1 and B1-2). A pipeline from the plant to the Morman Mesa would discharge the waste effluent solution. This waste, approximately 20 MGD at a concentration of 14,000 mg/l of TDS, would be pumped 11 miles through a 48-inch pipeline against a static head of 400 feet. The disposal area would consist of a 12-foot dike around 6,000 acres of land, sealed to prevent seepage, in order to store the brine and evaporate the liquid effluent. Assuming a reduced yearly evaporation rate, the brine disposal area would have a life expectancy of approximately 100 years. The fresh water effluent would discharge into a 72-inch pipline, 12 miles in length, and on into a 60-inch pipeline, 36 miles in length, requiring a lift of approximately 1,520 feet. This water, having a concentration of 500 mg/l, or less, of TDS, would be supplied to Las Vegas, North Las Vegas, and Henderson-Boulder City areas. This supply would amount to approximately 70 MGD, or 72,000 acre feet per year, which would be approximately 25 percent of the allocated 0.3 million acre feet from the Colorado River to the southern Nevada area. The sale of this water to municipal and industrial users in the southern Nevada area at $0.50 per thousand gallons would produce approximately $12,775,000 per year in revenue. A supplemental feature of this plan would be to construct a ditch with a dike on the east side between the Overton Arm of Lake Mead and the saline

springs some 8 miles south of the diversion dam. This ditch would collect the discharge from the springs and the natural runoff from precipitation. The collected water would then be pumped through an 8-inch pipeline into the desalination plant.

The total volume of water and tons per day of TDS eliminated from entering Lake Mead and processed in the plant would be approximately 90 MGD and 1,190 tons per day.

C. Estimated Cost

The following Table B1-3 summarizes the construction and annual cost of the proposed control method. The total construction cost for this project is estimated to be $66,910,000 with an estimated annual cost of approximately $12,922,700. After the reduction to account for the $12,775,000 of revenue for the water sales, the net annual cost is $147,700.

It is recognized that there may be some additional costs to be allocated to this project such as power loss due to flow reduction into Lake Mead under certain conditions, and perhaps a cost for disposal of fuel residue depending upon the type of fuel utilized.

D. Estimated Benefits

The reduction of salinity below Hoover Dam, resulting from the deletion of the Muddy and Virgin River flows, would amount to approximately 15 mg/l. These benefits would accrue to the downstream users, (see Table B1-4). The benefits to the users of the desalinated water in the Las Vegas area would be a reduction of TDS from 680 mg/l to 500 mg/l, or at least 180 mg/l. The overall reduction of the total Las Vegas water supply would be approximately 45 mg/l. An additional decrease of TDS concentration of approximately 100 mg/l in the

return flow in the Las Vegas Wash would have supplemental benefits on the reduction of TDS concentrations below Hoover Dam.

TABLE B1-3

VIRGIN RIVER PROJECT
CONSTRUCTION COST ESTIMATES - ANNUAL COSTS

	Storage Dam	~~70~~ 50 MGD Desalination Plant	Brine Disposal	Fresh Water Aqueduct	Rogers Spring Collection	Total
CONSTRUCTION COSTS	$ 7,500,000	$ 35,000,000	$ 5,200,000	$ 19,000,000	$ 210,000	$ 66,910,000
Annual Cost:						
Interest & Amortization[1/]	248,000	1,400,000	172,000	577,000	7,000	2,404,000
Operation & Maintenance	75,000	7,500,000	300,000	2,630,000	13,700	10,518,700
TOTAL ANNUAL COST						12,922,700
Sale of Water:						
To Municipal & Industrial @ ~~$0.50~~ $0.30 per 1,000 gal.						~~12,775,000~~
NET ANNUAL COST						147,700

1/ 3 1/8 percent interest at 100 years, except Desalination Plant - 3 1/8 percent at 50 years.

TABLE B1-4

ESTIMATED AVERAGE ANNUAL FLOW & QUALITY CONDITIONS AT HOOVER DAM
AFTER DEVELOPMENT OF DIXIE, MOAPA & PROPOSED DESALINATION PROJECTS

	Flow	TDS	
	1000 ac-ft	mg/l	Tons 1000's
Annual Reduction to Lake Mead			
From Virgin River	78.2		376.4
From Rogers Spring	.7		3.
From Overton Arm	.4		14.7
From Upper Moapa Project	4.5		18.2
From Moapa Pumping Project	22.0	680	20
TOTAL ANNUAL REDUCTION	105.8[1/]	3,020	432.3
Effect of Annual Reduction at Hoover Dam			
Present Conditions	11,978	680	11,114
Total Annual Reduction	106	3,020	432
FUTURE CONDITIONS AT HOOVER DAM	11,872	665	10,682

1/ For Moapa Valley Pumping Project, divert 22,000 acre feet @ 680 mg/l TDS, and 9,000 acre feet @ 1,500 mg/l from upper Moapa Valley. Return under salt balance @ 1/2 flow (see Moapa Valley Report, Bureau of Reclamation 1963).

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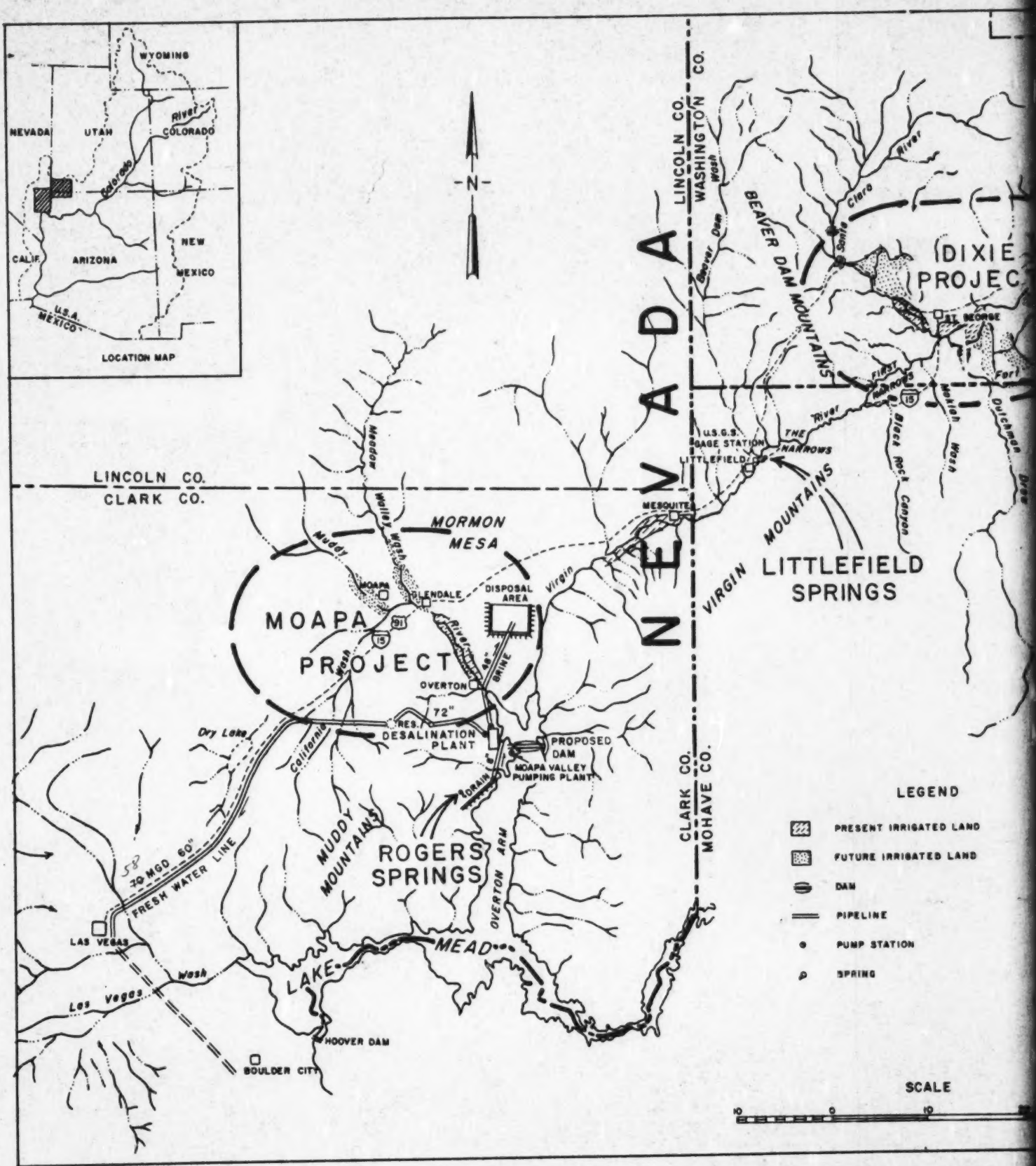
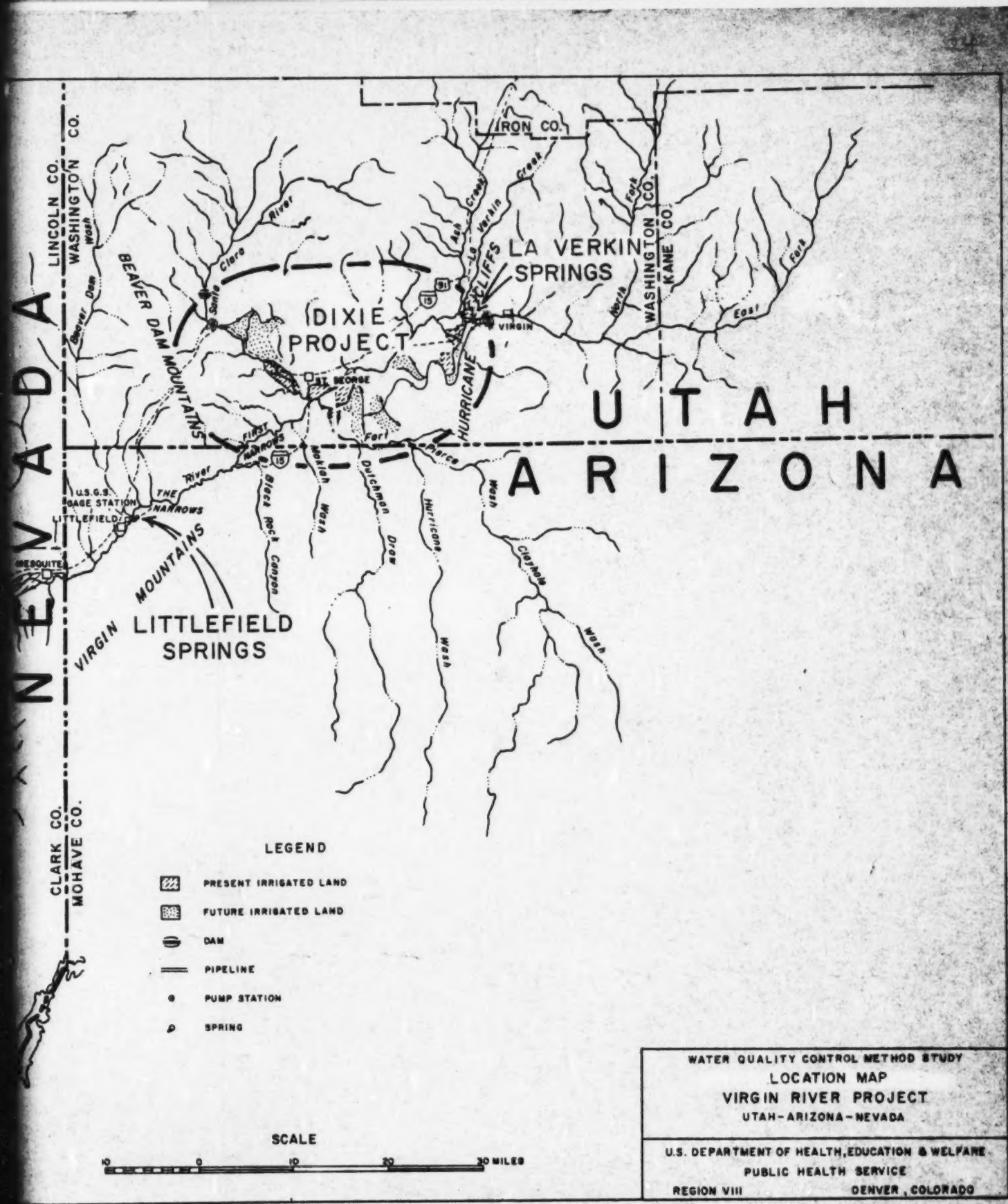
Moapa Valley Pumping Project Plan, Bureau of Reclamation, U. S. Department of the Interior.


WYOMING
NEVADA
UTAH
COLORADO River
Colorado
CALIF.
ARIZONA
NEW MEXICO
U.S.A.
MEXICO
LOCATION MAP
N
NEVADA
LINCOLN CO.
WASHINGTON CO.
Beaver Dam Wash
BEAVER DAM MOUNTAINS
Santa Clara River
DIXIE PROJEC
ST. GEORGE
Fort
FIRST NARROWS
Virgin River
Black Rock Canyon
Muddy
Quicksand Draw
U.S.G.S. GAGE STATION LITTLEFIELD
THE NARROWS
LINCOLN CO.
CLARK CO.
MESQUITE
MORMON MESA
Meadow
Valley Wash
Muddy
MOAPA
GLENDALE
DISPOSAL AREA
Virgin
MOAPA PROJECT
River
48" BRINE
OVERTON
72"
RES.
DESALINATION PLANT
PROPOSED DAM
MOAPA VALLEY PUMPING PLANT
Dry Lake
California
Lorain
MUDDY MOUNTAINS
ROGERS SPRINGS
OVERTON ARM
CLARK CO.
MOHAVE CO.
VIRGIN MOUNTAINS
LITTLEFIELD SPRINGS
30 MGD 60" FRESH WATER LINE
LAS VEGAS
Wash
Las Vegas
LAKE MEAD
HOOVER DAM
BOULDER CITY
LEGEND
PRESENT IRRIGATED LAND
FUTURE IRRIGATED LAND
DAM
PIPELINE
PUMP STATION
SPRING
SCALE
10
0
10



WATER QUALITY CONTROL METHOD STUDY

LOCATION MAP

VIRGIN RIVER PROJECT

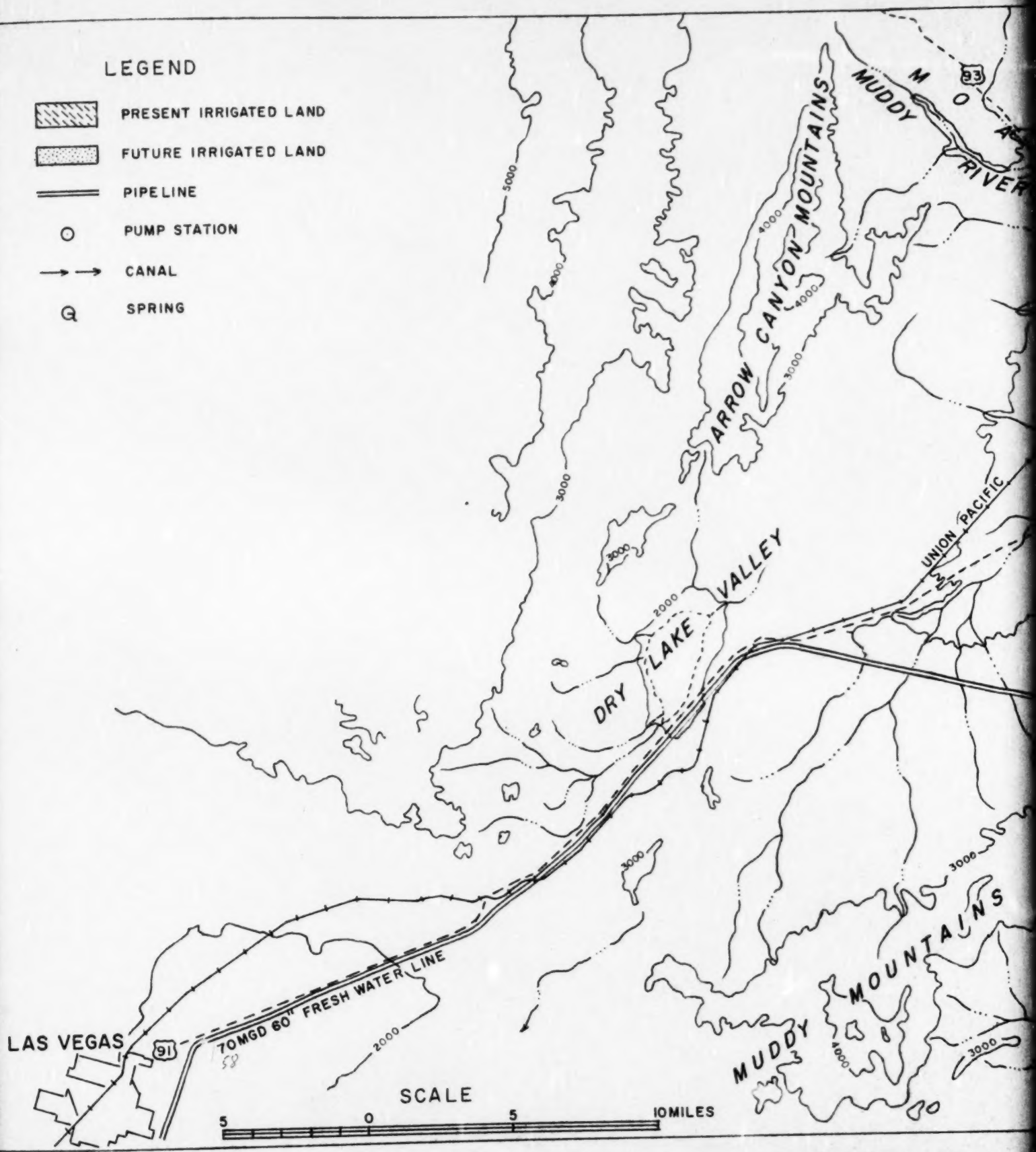
UTAH-ARIZONA-NEVADA

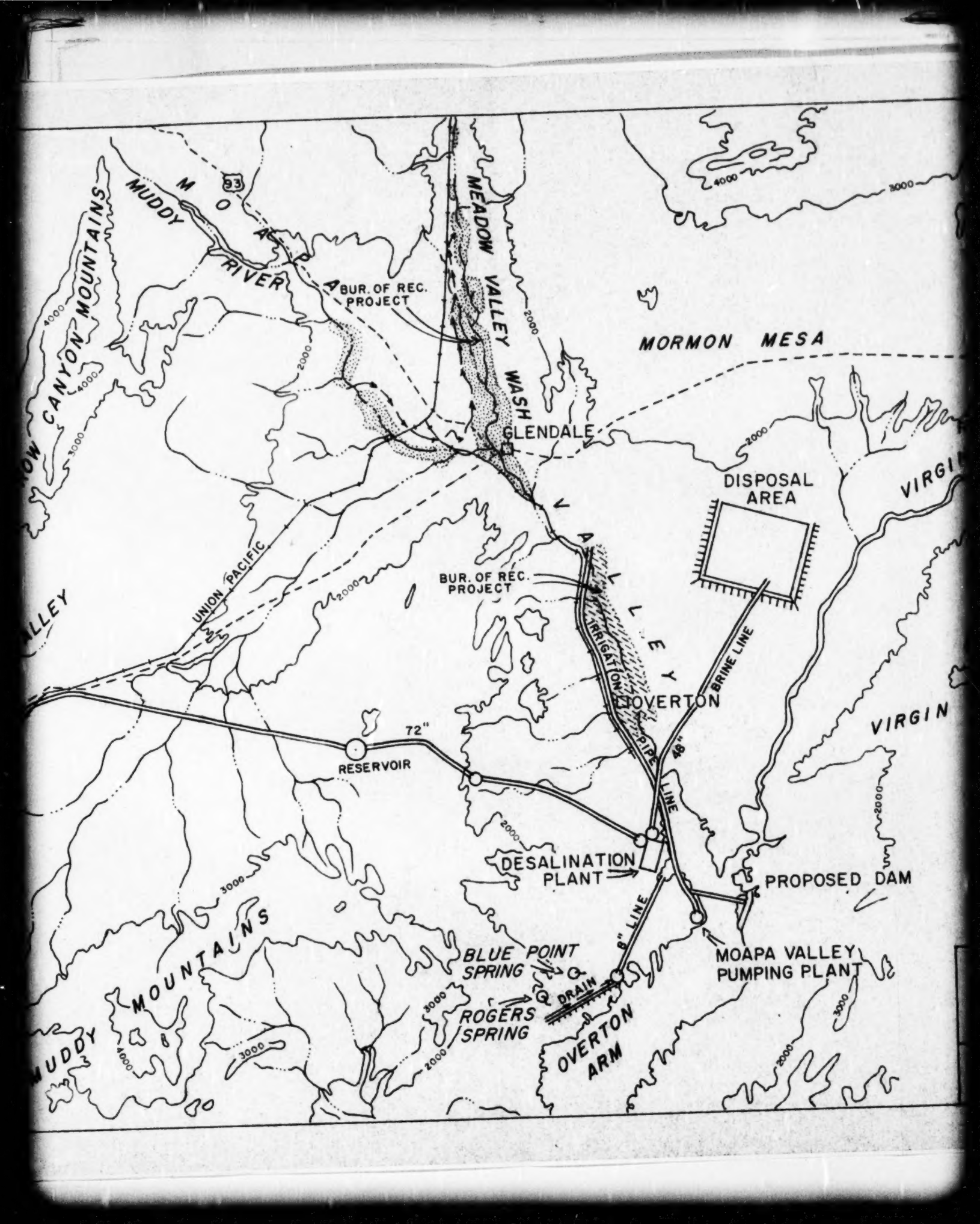
U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE

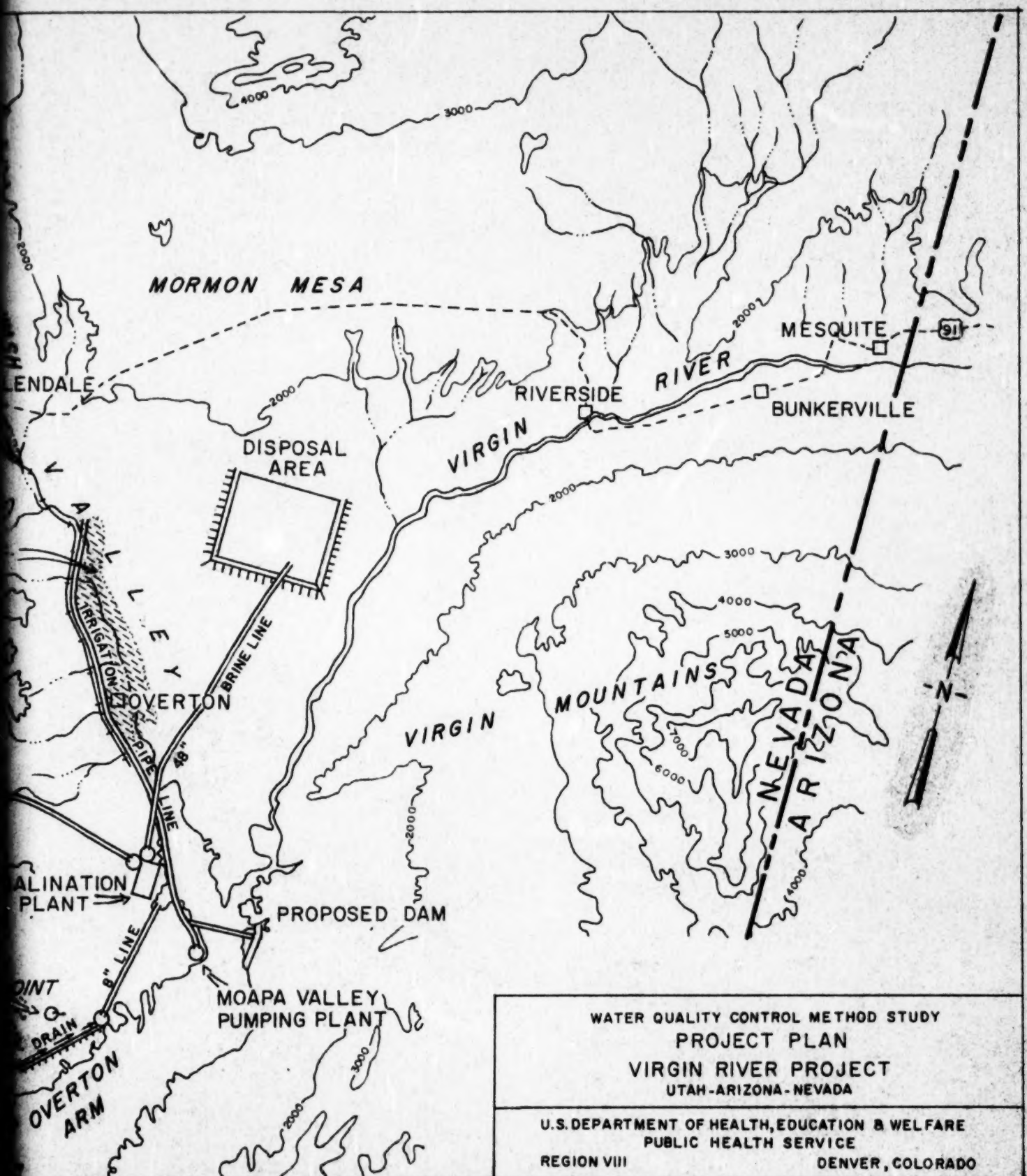
PUBLIC HEALTH SERVICE

REGION VIII DENVER, COLORADO

FIGURE B1-1


LEGEND
PRESENT IRRIGATED LAND
FUTURE IRRIGATED LAND
PIPELINE
PUMP STATION
CANAL
SPRING
MUDDY RIVER
93
ARROW CANYON MOUNTAINS
UNION PACIFIC
DRY LAKE VALLEY
LAS VEGAS
91
70 MGD 60" FRESH WATER LINE
MUDDY MOUNTAINS
SCALE
5 0 5 10 MILES
5000
4000
3000
2000


MUDDY RIVER
93
MOAPA
MEADOW VALLEY WASH
BUR. OF REC. PROJECT
MORMON MESA
GLENDALE
DISPOSAL AREA
VIRGIN
UNION PACIFIC
BUR. OF REC. PROJECT
IRRIGATION PIPE LINE
OVERTON
BRINE LINE
48"
72"
RESERVOIR
DESALINATION PLANT
PROPOSED DAM
8" LINE
MOAPA VALLEY PUMPING PLANT
BLUE POINT SPRING
DRAIN
ROGERS SPRING
OVERTON ARM
MOUNTAINS
4000
3000
2000



WATER QUALITY CONTROL METHOD STUDY

PROJECT PLAN

VIRGIN RIVER PROJECT

UTAH-ARIZONA-NEVADA

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PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

FIGURE BI-2